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ORIGINAL RESEARCH–FACIAL PLASTIC AND RECONSTRUCTIVE SURGERY

Fracture patterns of the nasal septum

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

ABSTRACT

OBJECTIVE: To evaluate fracture patterns of the nasal septum.
STUDY DESIGN: Cross-sectional cadaveric study.
SETTING: Synthes research laboratories, Philadelphia, PA.
SUBJECTS AND METHODS: Eighteen cadavers were divided into three groups. Group A was subjected to low-level force administered to the nasal tip. Group B underwent moderate-level force and group C high-level force. Cadavers subsequently underwent dissection of the nose and nasal septum.
RESULTS: Fracture patterns were apparent and related to the force applied. Fracture patterns were classified into three types depending on the location and extent. Group A was the most variable. Three cadavers were classified as type 1, two as type 2, and one as type 3. The average amount of force required to produce a fracture in this group was 100 N. Group B cadavers all developed type 3 fractures. Group C cadavers primarily developed type 3 fractures except for one that developed a type 1. Fractures were further classified in regard to the septum being displaced off the nasal spine.
CONCLUSION: Based on our observation, we conclude that fracture patterns of the nasal septum do exist and appear to be related to the amount of force sustained.

Fractures of the nasal bones and septum occur quite frequently, and, although much has been written concerning the subject matter, there still remains debate concerning proper management in these patients.[1-6] Most surgeons agree, however, that prompt identification of nasoseptal trauma and intervention is paramount to preclude post-traumatic nasal obstruction and cosmetic deformity.[4-7]

Septal fractures often occur in the presence of coexisting nasal bone fractures. Kim et al reported that 47 percent of nasal bone fractures are combined with septal fractures.[8] A majority of published data concerning treatment recommendations is specific to patients with both nasal bone and nasal septal fractures. There is a paucity of literature related to isolated septal fractures and the optimal treatment for patients suffering from this injury alone. In our study, we attempted to create isolated septal fractures in the cadaver model to understand better these specific injuries.

Materials and Methods

A total of 19 cadaver heads was used for the purpose of this study. Each cadaver was examined prior to inclusion to ensure that the septum was not obviously fractured and that the nasal spine was midline on the maxillary crest. No septal perforations were present. One cadaver was excluded during the study because it was noted to have previously undergone septoplasty with only an L strut remaining. Each cadaver was randomly assigned to a group. Characteristics pertaining to each cadaver are provided in Table 1.

Each of the three groups was then subjected to different levels of force directed at the nasal tip. Care was taken to avoid nasal bone trauma and prevent osseous fracture. Group A was exposed to low-level force applied to the nasal tip. Using a metered mallet, the force applied began at 50 N and was titrated up until a fracture of the nasal septum was identified. A force administered in this range was found to be comparable with that which one's septum would absorb during an average human punch. Group B was subjected to a single administration of moderate-level force between 230 N and 290 N. Force in this range was provided to simulate that sustained during a device-inflicted blow to the nasal septum. Group C was subjected to a single administration of high-level force between 450 and 500 N. Forces translated to the septum at this level were performed to mimic those that might be suffered during trauma sustained during motor vehicle collision. Following observation of a developed septal fracture, each cadaver underwent meticulous dissection of the nose and nasal septum. Data were recorded from the dissection including septum relationship to the nasal spine as well as fracture locations and characteristics. Institutional review board approval was not necessary for this cadaver study.

Results

During the course of the study, certain fracture patterns of the nasal septum became obvious. As a result, we were able to classify septal fractures into three types (Fig 1). Type 1

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Table 1
Cadaver characteristics and fracture types

Cadaver	Group	Sex	Force	Fracture type
1	Group A	Female	120 N	Type 1B
2	Group A	Female	120 N	Type 3A
3	Group A	Male	76 N	Type 2B
4	Group A	Male	120 N	Type 2B
5	Group A	Male	84 N	Type 1A
6	Group A	Male	82 N	Type 1B
7	Group B	Female	230 N	Type 3B
8	Group B	Female	250 N	Type 3B
9	Group B	Male	230 N	Type 3B
10	Group B	Male	230 N	Type 3B
11	Group B	Female	290 N	Type 3B
12	Group B	Female	250 N	Type 3B
13	Group C	Male	450 N	Type 1B
14	Group C	Female	470 N	Type 3B
15	Group C	Male	500 N	Type 3B
16	Group C	Male	450 N	Type 3B
17	Group C	Male	500 N	Type 3B
18	Group C	Female	450 N	Type 3B

fractures included those limited to a single fracture of the cartilage or bone not involving the osseocartilaginous junction. Type 2 fractures included those limited to a single fracture occurring at the osseocartilaginous junction (Fig 2). Type 3 fractures include those with multiple fractures at any location of the bony and/or cartilaginous nasal septum (Fig 3). Furthermore, we found it necessary to denote whether the septum was left intact on the nasal spine or if dislocation had occurred. Septums not displaced off the spine were classified as subset A. Septums displaced were classified as subset B.

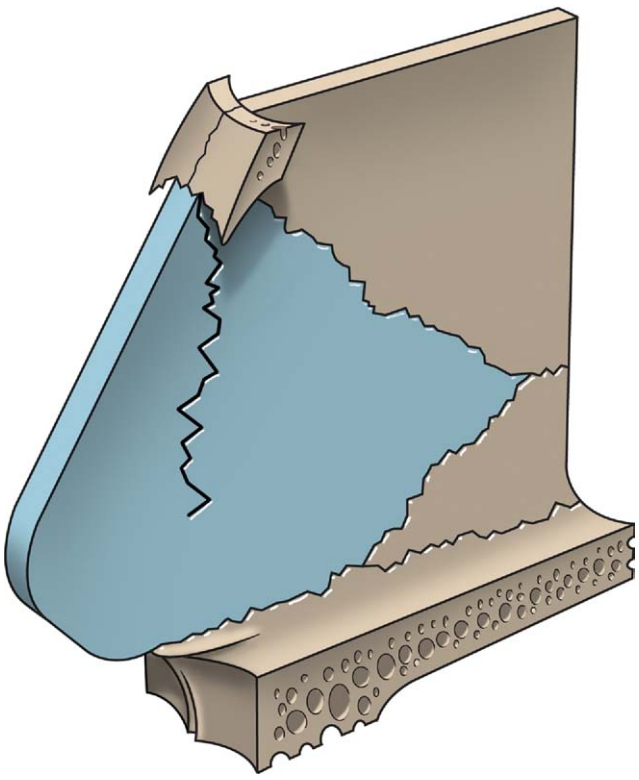

Figure 1 Type 1 fracture defined as a single fracture of the cartilage or bone not involving the osseocartilagenous junction.

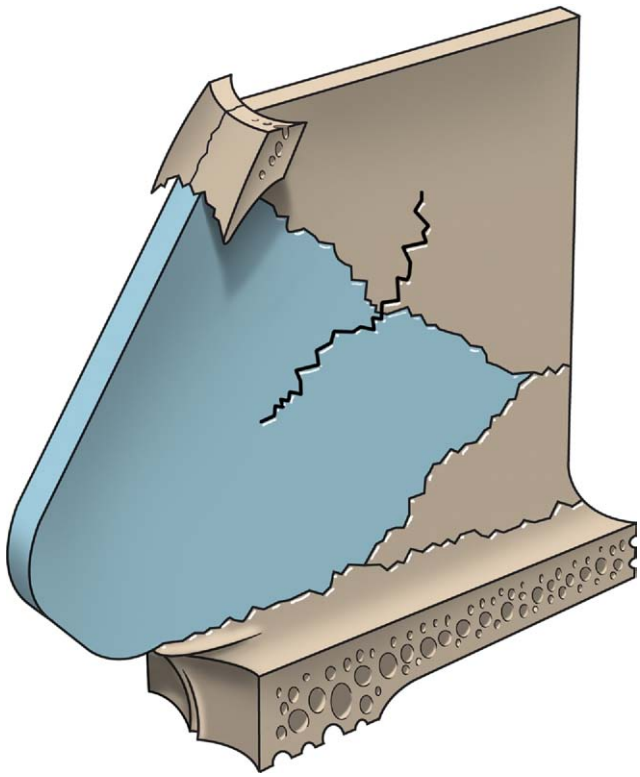

Figure 2 Type 2 fractures included those limited to a single fracture occurring at the osseocartilaginous junction.

Group A was the most variable pertaining to fracture classification. Three cadavers developed type 1 fractures with two of the three septums displaced off the nasal spine. Two cadavers in this group developed type 2B fractures, and the final cadaver developed a type 3A fracture. The amount of force required to generate an obvious fracture in group A ranged from 76 to 120 N with a mean of 100 N. Group B cadavers were consistently classified as type 3B. The average force applied in this group averaged 247 N. Group C cadavers all developed 3B fracture types, except for one cadaver that was found to have a type 1B fracture pattern. The average force applied in this group averaged 470 N. A majority of fractures began in proximity to the rhinion and extended in the direction of the anterior nasal spine. In all three groups, the cadavers classified as type 1 were found to have isolated cartilaginous septal fractures because none developed isolated fractures of the bony septum. There was significant variability in the anatomy of the osseocartilaginous junction (Fig 4).

Discussion

Injury to the nasal septum is quite common, and a thorough understanding of both the histologic components of the

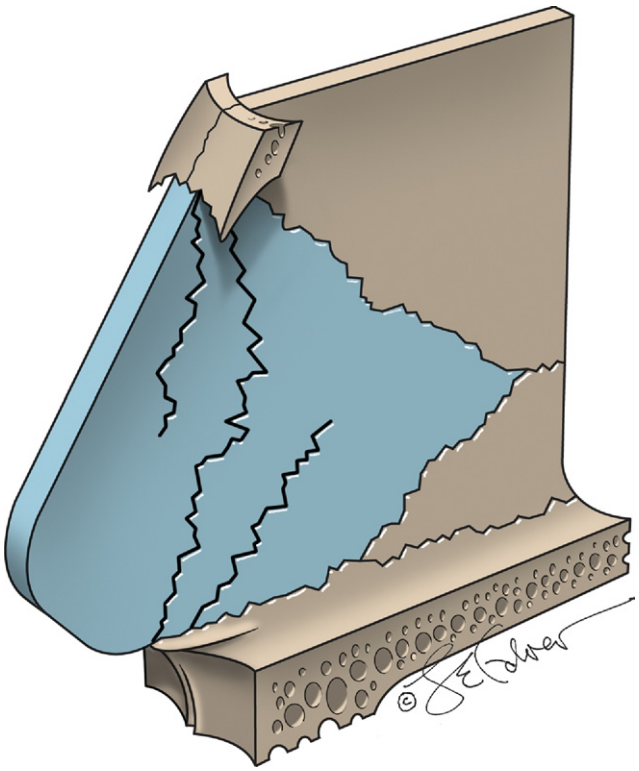

Figure 3 Type 3 fractures included those with multiple fractures at any location of the bony and/or cartilaginous nasal septum.

cartilage and gross interaction with adjacent bone and cartilage is fundamental for the surgeon to appropriately treat these patients. It has been known for some time that cartilage of the nasal septum possesses interlocking stresses that exist in a state of balance and may be released by fracture.[1] It is this principle that allows us to shape cartilage grafts during rhinoplasty by scoring tissue to release stresses. Fry was instrumental in reinforcing this concept both in the gross cadaver and in histologic examination.[1]

Fry would later report the clinical findings of 100 patients with nasoseptal trauma.[2] He described a basic pattern of the deviated nasal septum after trauma in which the cartilage directly behind the anterior nasal spine was curved into one nasal cavity with the free border projecting into the opposite nostril. Fry's observation is consistent with our findings in which quite commonly the fracture occurs at the area of the anterior nasal spine and the septum is displaced off into the nasal cavity. Fry also suggested that incomplete fractures were more difficult to treat because they created irreversible damage to the balance of the internal stress system of the septal cartilage.[1,2]

Deviation in the distal septum has also been shown to effect positioning of the lower lateral cartilages and could possibly lead to nasal tip deformity if not properly addressed.[4,9] Gunter and Rohrich emphasized the septum as the key structure to align and optimize nasal fracture management and to minimize the potential for secondary deformity.[10] Although extreme variation in the attachment of septum and lateral nasal cartilages exist, trauma to the nasal septum will inevitably compromise the adjacent cartilaginous structures.[11]

Harrison studied septal trauma in the cadaver with his findings differing slightly from our observations.[3] He reported that the nasal septum fractures occurred in a predictable manner, with the fracture line beginning just posterior to the anterior nasal spine and extending towards the osseous-cartilaginous junction. The fracture pattern continued to extend into the bony septum at the perpendicular plate of the ethmoid and then turned toward the cribriform plate, finally reentering the quadrilateral cartilage.[3] In our study, the most common fracture location was also just posterior the anterior nasal spine. However, the fractures more typically extended to the level of the rhinion. Occasionally, we noted a fracture in the direction of the osseous-cartilaginous junction but not extending into the bony septum.

Rhee et al reported their operative findings in patients undergoing treatment for simple nasal bone fractures.[7] Observations were made through a hemitransfixion incision at the time of surgery. Ninety-six percent of patients were found to have a coexisting septal fracture. In 79 percent of patients, either septoplasty or submucosal resection was undertaken for those fractures deemed severe.[7] Rhee et al described the most common fracture line beginning in the quadrilateral cartilage again just posterior to the anterior nasal spine. The fractures typically extended posteriorly in the cartilage several millimeters above its junction with the vomer and then entered the perpendicular plate of the ethmoid bone curving up toward the cribriform plate and finally reentering the quadrilateral cartilage similar to what Harrison had previously described. [3,7] The authors do note, however, that, in 21 percent of patients, a vertical fracture in the central portion of the cartilaginous septum developed. In 27 percent of patients, the fracture extended from the anterior maxillary crest to the perpendicular plate of the ethmoid in a stepladder pattern. Thirteen percent of patients developed comminuted septal fractures.[7] The differences noted by Rhee et al compared with our study may be related to the absence of coexisting nasal bone fractures in our study.

In his article discussing the biomechanics of the nasal septum related to trauma, Holt suggested that fractures are related to stresses occurring in certain locations.[12] Holt reported his surgical observations that cartilage of the nasal septum has increased thickness at areas connected to bone. This pattern of septal thickness has been previously studied and described by other authors.[3,5] With these areas containing an increased thickness, there exists a differential resistance to injury along the more widened buttresses as compared with the central and dorsal segments.[12] He also emphasized that the septum possesses a wedge shape and that external blunt trauma from the axial direction typically results in septal fracture above or anterior to the thick buttress. This explanation serves our findings well because the fractures most commonly occurred slightly anterior to the areas where the septum attaches to the rhinion and the anterior maxillary spine. Holt also stated that, because of the

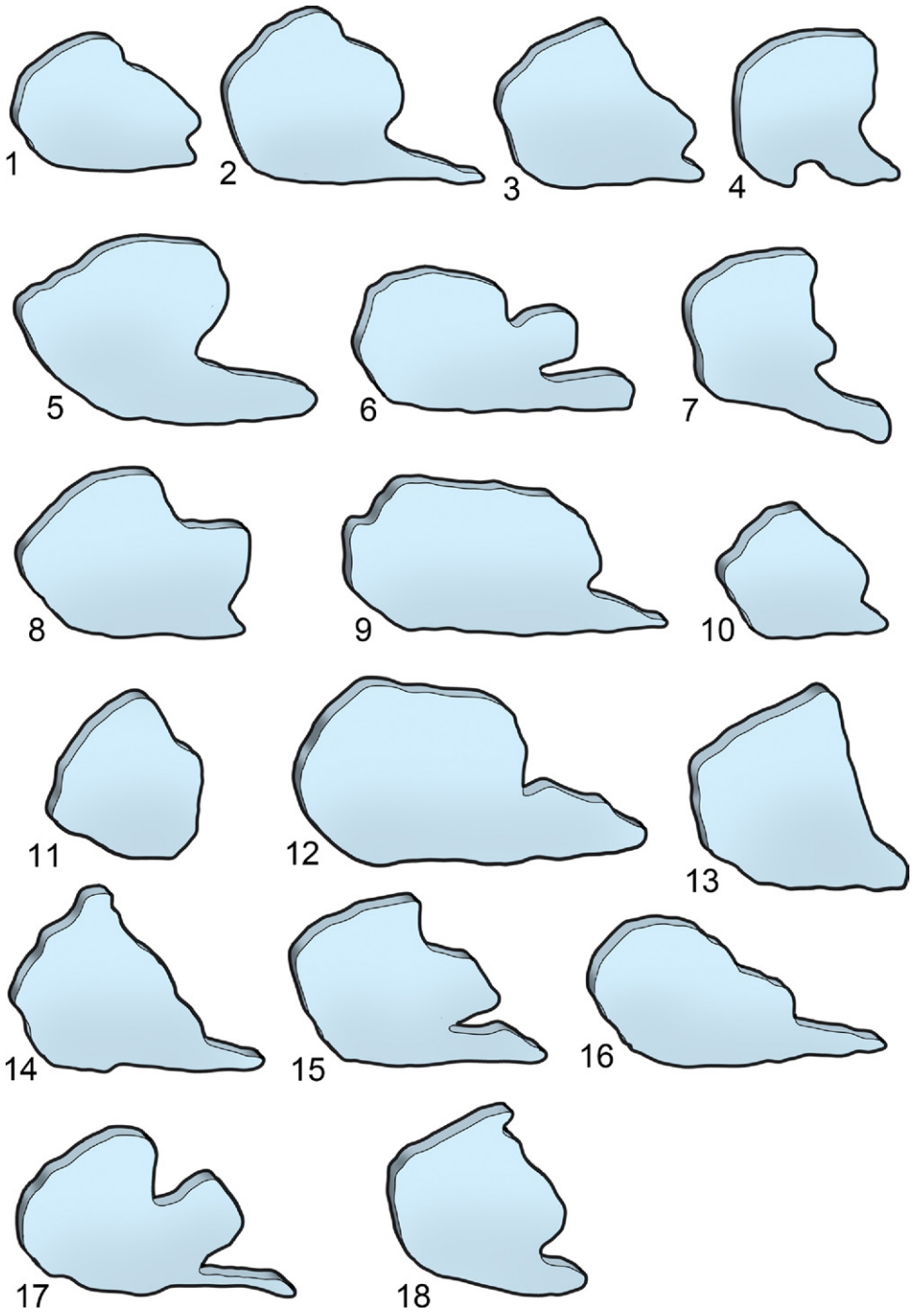

Figure 4 Variability in the anatomy of the osseocartilaginous junction.

difference in the coefficiency of elasticity between the bony and cartilaginous septum, the force is absorbed by the more anterior quadrilateral cartilage, meanwhile sparing the bony septum.[12] This principle would explain why we did not observe the bony fracture patterns previously described by Harrison[3] and Rhee et al.[7]

Injury to the nasal septum is common and often results in subsequent fracturing as well as dislocation from the nasal spine. Treatment options in the presence of coexisting nasal fractures have been previously suggested.[4,6] In those patients with an isolated septal fracture, the optimal intervention is less clear. Renner suggested closed reduction with intranasal packing for the simple septal injury in which the distal portion of the cartilaginous septum is alone involved.[13] Pollock stressed the surgeon having a low threshold for open reduction of the nasal septum specifically in those patients suffering from a moderate to severe septal injury.[6] The complexity regarding management stems from variations of the nasal septum and the fact that there may be unseen septal injury.[14,15] In these cases, the release of in-

terlocking stress may lead to obstruction and deformity as the healing process occurs. Based on our finding that, with moderate or high impact trauma, there most likely exists a type 3 injury, we suggest being more aggressive with these patients. Also common was the septum being displaced form the nasal spine. In our experience, this problem is much better addressed though a hemitransfixion incision as compared with closed reduction.

The findings in our study show a propensity for isolated septal fractures to occur through the cartilaginous septum typically extending from the anterior nasal spine towards the rhinion. Whether fractures involving the bony septum, cartilaginous septum, or a combination of both behave differently has yet to be fully elucidated. For the purpose of this study, we used a classification system that can be easily employed and may assist in future studies related to the development of treatment optimization.

Based on our observations, we conclude that fracture patterns of the nasal septum do exist and appear to be related to the amount of force sustained.

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Disclosures

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